Chapter 4 Lake Water Quality Assessment

4.1 Introduction

There are approximately 3,990 lakes, reservoirs and ponds over 2 acres in New Jersey, but of these, only about 60 are natural. The remainder are constructed impoundments. There are 380 public lakes (24,000 acres) and 64 reservoirs. Thus far, 376 lake bathing beaches at 310 lakes have been identified; some lakes have multiple beaches. Uses of New Jersey's lakes, reservoirs and ponds vary and can include potable water supply, water storage, recreational boating, fishing and swimming. These waterbodies also provide habitat for a variety of aquatic life and wildlife.

This chapter focuses on aquatic life and recreational designated use assessments for lakes. This section also discuses eutrophication and its impact on the recreational quality of lakes. Fish consumption advisories for lakes are discussed in Part III, Chapter 7: Public Health and Aquatic Life Concerns. As discussed in Part III, Chapter 3.4: Drinking Water Designated Use Assessment, water supply uses will be assessed in the Source Water Assessment Program.

4.1.1 Lakes Aquatic Life Designated Use Assessment Method

The aquatic life use support assessment for lakes was based upon warm water fishery assessments supplied by the Department's Bureau of Freshwater Fisheries (BFF). This assessment has been improved to provide a direct indicator of aquatic life designated uses. Previous aquatic life assessments for lakes were based on lake trophic status, an indirect indicator of aquatic life uses.

In previous New Jersey Water Quality Inventory Reports, eutrophic lakes were classified as "fully supporting aquatic life designated use, but threatened". However, aquatic plants, which grow in abundance in eutrophic lakes, provide food and habitat to the lake fish community. Many warm-water fish communities can thrive under moderate eutrophic conditions but may be impaired by severe eutrophication when dissolved oxygen levels are severely depressed and/or aquatic vegetation becomes excessively dense. Clean Lakes Program studies of trophic status identified recreational and aesthetic impairments, not impairments to fisheries. Therefore, trophic status assessments are included in Chapter 4.3: Lakes Recreational Designated Use Assessment: Aesthetics.

Assessments of lake fisheries are performed based upon a priority list provided in the Division of Fish and Wildlife's Warmwater Fisheries Management Plan (NJDEP, 1998a) which serves as the primary guidance for warmwater fisheries management for the Department. Lake assessment frequencies vary depending upon the lake in question and its individual management needs.

Fish populations are sampled using methods such as electrofishing (spring or fall), shoreline seining (summer to assess fish reproduction), and/or gillnetting (fall). In addition, basic water chemistry parameters such as dissolved oxygen, pH and nutrients are recorded during the summer months when the water columns are most stratified. Fish population data are then assessed by experienced fishery biologists for the purpose of determining a lake's actual or

potential recreational value as a fishery and recommendations are made to maintain or enhance the resource.

It is important to note that although the Bureau of Freshwater Fisheries is principally concerned with the recreational value of the fisheries they assess, the assessments they provide are based upon the diversity of a wide range of fish species and not just species of recreational value. This is because many sport fish are carnivorous and depend upon an abundant and diverse forage base to support their populations. Species stocked by the Bureau are also identified and addressed in the assessments.

For this 2000 New Jersey Water Quality Inventory Report, assessments were supplied by Bureau of Freshwater Fisheries based upon fish inventories of selected lakes and reservoirs of over 100 acres in size with public access for recreational fishing. This resulted in 10 lakes and reservoirs totaling 9,875 acres being assessed. Assessment dates range from 1993 to 2000. Assessments conducted during or after 1995 are considered "monitored" for this report while those conducted prior to 1995 are considered "evaluated". NJDEP plans to expand the use of fisheries assessments in future Water Quality Inventory Reports. Table 4.1.1-1 describes the aquatic life use assessment method based on Bureau of Freshwater Fisheries lake inventories.

Table 4.1.1-1: Lake Aquatic Life Designated Use Assessment Method

Aquatic Life Assessment	**Fishery Description**
Full Support	Fishery is well balanced, exhibiting good diversity. Consistent recruitment.* No one species dominating the community. No observable factors limiting the fishery.
Full Support but Threatened	Fully supported fishery, however, anticipated changes in surrounding land use, lake water levels or in-lake water quality have the potential to cause future declines in fishery quality.
Partial Support	Fishery present, however, fish diversity not at potential expected for the type of lake in question. Predator to prey populations are not in balance, inconsistent recruitment*.
No Support	Fishery exhibits poor diversity. Fishery dominated by a few tolerant species (carp, goldfish, mudminnows, killifish, etc) and/or general overall number of individuals is low. Poor recruitment* and growth of individuals.
* Recruitment refers to the number of young fish which survive to ultimately become large enough to reproduce and/or become harvestable. For example: reproduction of a number species of fish in a lake may be good but there may be insufficient habitat cover resulting in many of these fish being eaten by their larger counterparts before they grow to sufficient size to either reproduce or be sought after by anglers. In such a scenario, recruitment is regarded as poor.	

4.1.2 Lakes Aquatic Life Designated Use Assessment Results

There were 10 lakes described by Fish and Wildlife totaling 9,875 acres of which 5,950 acres fully support the use, 2,635 acres are threatened, 1,290 acres partially support the use and 0 acres do not support the use. Results are summarized below on Table 4.1.2-1

Table 4.1.2-1: Lakes and Reservoirs Assessment Results Using Fisheries Data

County	Lake Name	Acres	Use Assessment	Latest Assessment Date
Cumberland	Union Lake	898	full support	1994
Hunterdon	Round Valley Reservoir	2,350	full support	1996
Hunterdon	Spruce Run Reservoir	1,290	partial support	1997
Monmouth	Manasquan Reservoir	720	full support	1996
Morris	Lake Hopatcong	2635	threatened	1995/1996
Morris	Budd Lake	376	full support	1997
Passaic	Monksville Reservoir	505	full support	2000
Sussex	Canistear Reservoir	350	full support	1993
Sussex	Lake Aeroflex	101	full support	1995
Warren	Merrill Creek Reservoir	650	full support	2000

The results of designated use assessments provided by the Bureau of Freshwater Fisheries are summarized below on Table 4.1.2-2.

Table 4.1.2-2: Lakes Aquatic Life Designated Use Assessment Summary (in acres)

Use Support Category	Acres
Full support	5,950
Full support but threatened	2,635
Partial support	1,290
No support	0
Total Acres Assessed	**9,875**

4.1.3 Source and Cause Assessment

Spruce Run Reservoir in Hunterdon County was classified as partially supporting aquatic life designated uses. This impairment has been attributed to frequent and significant water withdrawals which cause significant oscillations in water levels. This has eliminated all vegetation within the reservoir, a critical component of fish cover. The lack of adequate cover within the reservoir has affected the recruitment of a number of game species. Recruitment is defined on Table 4.1.2-1. In addition the reservoir receives nutrient laden runoff during storm events from the upstream watershed and exhibits dense algal blooms during the summer months. The Bureau of Freshwater Fisheries has found dissolved oxygen levels from approximately 12 feet down to the lake bottom (70 ft.) are routinely reduced to 0 mg/l DO during the summer months. Spruce Run Reservoir was not studied by the Clean Lakes Program.

Lake Hopatcong was classified as fully supporting aquatic life uses but threatened due to accelerated eutrophication brought about by nonpoint source pollution from the communities

immediately surrounding the lake, especially from septic systems. Lake Hopatcong was also classified as eutrophic by the Clean Lakes Program.

4.1.4 Strategies to Protect and Enhance Aquatic Life Uses in Lakes

Implement management measures for fisheries: Numerous management measures are identified in the Warmwater Fisheries Management Plan such as lake dredging when needed, aquatic vegetation control and angler education.

A Lake Restoration and Management Advisory Task Force ("Lakes Task Force") has been created through an Executive Order by the Governor and is charged with examining the causes of lake eutrophication, and making recommendations regarding the types of measures necessary to restore and properly manage lakes, and ways to finance such work. The task force includes members from the NJDEP, State Treasury, Community Affairs, the New Jersey Environmental Infrastructure Trust and members of the Legislature.

Expand the use of direct measures of aquatic life designated use status: NJDEP plans to make wider use of fishery inventories provided by the Department's Bureau of Freshwater Fisheries. In addition, NJDEP and USEPA Region II are developing rapid bioassessment protocols for lakes. Once the protocols are completed and sufficient data are available, these new data will be integrated into the Aquatic Life Use support status of public lakes for future Water Quality Inventory Reports. The assessments will be conducted using a multi-metric approach similar that which is being developed for rivers and streams, taking into account both finfish and aquatic invertebrate communities.

Additional lake management strategies to control eutrophication are discussed under section 4.3, Lake Recreational Designated Use: Eutrophication and Aesthetics

4.2 Lakes Recreational Designated Use Assessment: Sanitary Quality

Lake bathing beaches provide recreational swimming opportunities to inland communities. Lake bathing beaches are monitored for sanitary quality by county, local and private beach operators with oversight and program coordination from New Jersey Department of Health and Senior Services (NJDHSS). NJDEP's Cooperative Coastal Monitoring Program recently began to compile NJDHSS data so that a more comprehensive picture of the quality of all NJ bathing beaches could be provided. In addition, many of the environmental programs available to maintain and improve lake water quality are operated through NJDEP. Through the Division of Watershed Management, projects needed to protect and improve lake bathing beaches can be cooperatively prioritized and implemented.

The following subgoal and objectives related to lake bathing beach sanitary quality were developed through NEPPS. (NJDEP, 1999).

Subgoal: Protect recreational designated uses in tidal and non-tidal waters.

Objective: Maintain and improve the current number and quality of suitable lake, ocean and bay bathing beaches in NJ

Milestone: By 2000, the recreational lake beach waters will have been assess and water quality improvement projects will have been prioritized.

4.2.1 Lake Recreational Designated Use Assessment Method

The sanitary quality of water at the bathing beach is monitored by the entity responsible for operating the beach, including county and local health agencies and private entities. Some lakes included in this assessment are privately owned and operated, including camps, private schools or lake associations.

NJDHSS regulations govern the collection of these data and beach closures based on elevated levels of fecal coliform (FC). Under these regulations, fecal coliform bacteria are monitored at least weekly during the bathing season (typically Memorial Day to Labor Day). If concentrations exceed 200 FC/ 100 ml sample, the beach sampled again the following day and is closed and remains closed until levels meet the standard. Sanitary surveys are performed to identify and address bacterial pollution sources. As discussed in Chapter 3.3: Rivers and Streams Recreational Designated Use Assessment, levels of fecal coliform bacteria are used to indicate the presence of fecal pollution which may be harmful to human health. Data for this assessment were compiled by NJDEP's Cooperative Coastal Monitoring Program from the NJDHSS. This initial assessment relied on fecal coliform data provided by NJDHSS. Ideally, future assessments will rely on beach closure data as well.

The following assessment method was adapted from USEPA Guidance for Preparation of Water Quality Inventory Reports (EPA, 1997).

Table 4.2.1-1: Lakes Recreational Designated Use Assessment Method

Use Support	Definition
Full	Less than 10% of samples exceed 200 FC/100 ml
Full but Threatened	Less than 10% of samples exceed 200 FC/100 ml but statistically significant trends indicate that greater than 10% of samples will exceed the standard by the next reporting cycle (currently 2 years)
Partial	Greater than 10% but less than 25% of samples exceed 200 FC/100 ml
None	More than 25% of samples exceed 200 FC/100 ml

To date, 376 lake bathing beaches located on 310 lakes have been identified; some lakes have more than 1 beach. Recreational designated use attainment was assessed separately at each beach. Since data were collected within the last 5 years, this assessment is based on monitored results.

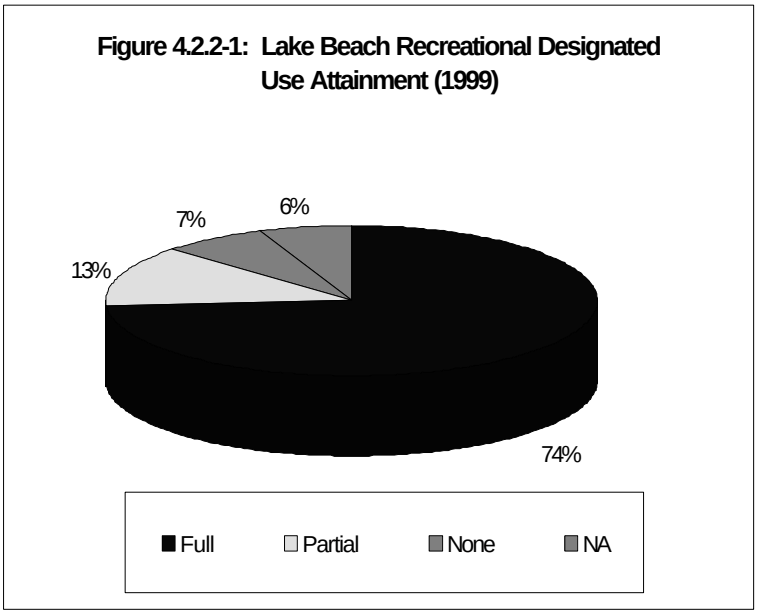
Spatial Extent of Assessment: USEPA Guidance requests that designated use assessments for lakes be reported in lake acres. To date, 167 of 310 lakes (17,473 acres) with bathing beaches have been located on GIS. For mapped beaches, the assessment results are applied to the entire lake or proportionally assigned based on the number of beaches at the lake. The remaining lakes are reported by beach for this report. Efforts are underway to map the remaining beaches. This work is expected to be completed for the 2002 Water Quality Inventory Report.

4.2.2 Lakes Recreational Designated Use Assessment Results

The percent of samples that exceeded 200 FC/ 100ml during 1999 were used to assess recreational designated uses. Results are summarized on Figure 4.2.2-1 below.

As shown on Figure 4.2.2-1, 277 (74%) lake bathing beaches provide excellent recreational swimming opportunities (full support) and 50 (13%) exhibited partial support. Only 27 (7%) exceeded the primary contact standard in more than 25% of samples collected during 1999 (no support). It was not possible to assess recreational designated uses at 22 lakes (6%) because the beach was closed or data were not provided. The rationale for closing lake beaches or not providing data were not readily available. Results for individual lakes are provided in Table A4.2.2-1 and Figure A4.2.2-1 in the Appendix.

Figure 4.2.2-1: Lake Beach Recreational Designated Use Attainment (1999)



For the 167 lakes that have been located on GIS, 11,343 acres (65%) fully support recreational uses, 4571 acres (26%) partially support recreational designated uses; 906 acres (5.1%) do not support recreational uses; and 653 acres (3.7%) were not assessed. As discussed above, efforts are underway to locate the remaining lakes on GIS, facilitating a comprehensive spatial assessment of lake bathing beaches.

4.2.3 Lake Recreational Designated Use Source and Cause Assessment

There were 27 lakes with 44 beaches that were studied in the Clean Lakes Program and identified as eutrophic. These lakes are identified in the Appendix on Table A4.3.1-1: Lakes Trophic Assessments. Of these, 28 beaches (64%) fully supported recreational uses in 1999; 6 beaches (14%) partially supported recreational uses and 10 beaches (23%) did not support recreational uses. Additional information is needed to determine if eutrophic conditions were related to sanitary quality issues at lakes with elevated fecal coliform levels.

In general, sources and causes of lake bathing beach closures are very similar to those affecting rivers and streams. The reader is referred to Part III, Section 3.3.3 for additional information. Additional site specific information regarding sources of fecal coliform pollution at lake bathing beaches is expected to become available through the Watershed Management Program.

4.2.4 Maintaining and Improving Lake Recreational Designated Uses

Continue remediation efforts for eutrophic conditions at lakes with beaches: Through the Clean Lakes Program, remediation efforts for eutrophic conditions are ongoing or have been completed at several lakes with one or more bathing beaches, including Cranberry, Greenwood, Hammonton, Hopatcong, Manahawkin, and Swartswood. Additional information is provided in the Appendix on Table A4.3.3-1: Lake Remediation under the Clean Lakes Program. Through the New Jersey Lakes Bond Act, remediation efforts are ongoing at several lakes with one or more bathing beaches, including Cranberry, Greenwood, Hammonton, Hopatcong, Mohawk, Pine, Round Valley, Swannanoa, Swartswood and Sylvan. Additional information is provided in Appendix A4.3.3-2: FY96 Lakes Bond Act Projects.

Continue and expand cooperative assessments with NJDHSS: The lake bathing beach data for this assessment were provided through the cooperative efforts of the Cooperative Coastal Monitoring Program and the NJDHSS. This initial effort made the lake bathing beach assessment possible. Future cooperative efforts should explore the exchange of lake beach closure data with NJDEP. This dataset would facilitate development of a swimmable index based on beach closure rates for ocean, bay and lake bathing beaches.

Identify and prioritize lake improvement projects: Through watershed management, specific sources of FC pollution at lake bathing beaches will be identified and lakes will be prioritized for improvement projects.

The Governor's Lake Restoration and Management Advisory Task Force ("Lakes Task Force") See section 4.1.5 "Strategies to Protect and Enhance Aquatic Life Uses in Lakes".

Improve spatial assessment: NJDEP and NJDHSS are working cooperatively to locate the remaining 143 lakes on GIS. The results will be used to complete the comprehensive assessment of lake bathing beaches for the next Water Quality Inventory Report.

Develop the lake beach component of the “swimmable index”: NJDEP is beginning development of a “swimmable index” that will integrate beach closure rates for ocean, bay and lake bathing beaches. The index will distinguish beach closures due to water quality issues from precautionary beach closures. Lake beach closure data are needed to improve the index.

4.3 Lake Recreational Designated Use: Aesthetics

Many of the lakes in New Jersey are constructed impoundments which are highly prone to eutrophication. Eutrophication occurs naturally as lakes age, however, this process can be accelerated from excessive inputs of nutrients and suspended sediments from the surrounding watersheds. Eutrophic lakes are characterized by excessive growth of aquatic weeds and algae,

shallow depths as sediments fill the lake in, elevated temperatures and low dissolved oxygen. The excessive algal growth, be it planktonic or rooted, often create aesthetically unpleasant conditions for swimming and difficult conditions for boating. As discussed above, additional information is needed to evaluate the role of eutrophic conditions and sanitary quality at lakes with beaches.

The Clean Lakes Program was designed by USEPA to facilitate identification and remediation of impaired lakes. Public lakes with water quality issues were identified by lake associations, municipalities or other entities; studies were conducted to characterize water quality and as funding was available, remediation projects were conducted. Also during the 1980's and early 1990's, NJDEP collected water quality data on a number of public lakes. Data collection included a suite of indicators such as total phosphorus, Secchi disk transparency and chlorophyll a levels to determine the trophic state of lakes. Much of the impairments brought to the Department's attention through the Clean Lakes Program centered around nuisance algal growth impairing swimming and in some cases boating.

The Clean Lakes Program has assessed a total of 116 public lakes representing 10,462 acres. This represents 31% of public lakes and 44% of public lake acres. Many Clean Lakes assessments had been performed in the 1980's and early 1990's. Since these assessments are more than 5 years old, they are considered to be based on evaluated data.

In the past, lake trophic assessments had been used in Water Quality Inventory Reports to assess lake Aquatic Life Designated Use Support. Beginning in this Report, Aquatic Life Use Support in lakes is based upon warm water fishery assessments supplied by the Department's Bureau of Freshwater Fisheries (BFF) (see section 4.1 above).

4.3.1 Clean Lakes Program Eutrophication Assessment Results

Table A4.3.1-1 in the Appendix provides a list of lakes assessed by the Clean Lakes Program and the assessment results. Of 116 public lakes assessed by the Program (10,462 acres), 4 lakes (206 acres): Lake Atsion, Tuckahoe Lake and Turnmill Lake were assessed as mesotrophic. The remaining 112 lakes (10,256 acres) were assessed as eutrophic. Eutrophic lakes have been included on Impaired Waterbodies Lists.

Subsequently, extensive remediation and a TMDL were completed for Upper Sylvan Lake in Burlington County and this lake (4 acres) is now regarded as mesotrophic. Additional information on this TMDL is provided in the Appendix to Part II, Chapter 3: Water Pollution Control Programs.

A subset of 12 lakes assessed under the Clean Lakes Program specifically for restoration (Phase I assessment) have undergone remediation. The remediation of Manahawkin Lake (45.5 acres) was successful and this lake is now regarded as mesotrophic. For the remaining lakes projects, remediation efforts have addressed some, but not all, of the issues associated with eutrophication. A list of lakes with ongoing Clean Lakes Program projects, impairments, method of remediation and current status are summarized in the Appendix on Table A4.3.3-1. In addition, the New

Jersey Lakes Bond Act provided funds for additional remediation projects which are summarized in the Appendix on Table A4.3.3-2.

4.3.2 Lake Eutrophication Source and Cause Assessment

Much of the Department's information regarding lake eutrophication comes from the Clean Lakes Program. As reported in earlier Water Quality Inventory Reports, lake eutrophication is a widespread issue in New Jersey and is characterized by elevated levels of suspended sediment, nutrient and algal concentrations. Aquatic life may be stressed due to dissolved oxygen fluctuations and in extreme situations, fish kills may occur. Eutrophic conditions generally lower the aesthetic and recreational value of the lake. Although all lakes naturally progress to eutrophic conditions, then become wetlands (especially those created as stream impoundments), this process is being accelerated by excessive inputs of nutrients and suspended sediments from point and nonpoint sources. In addition, an important factor to consider in New Jersey lakes is that most of them are shallow stream impoundments constructed for a variety of purposes including flood and sediment control. These shallow impoundments are highly prone to eutrophication. Through restoration projects, described below in Section 4.3.3, site-specific sources of nutrients and suspended sediment as well as management measures are identified for each lake.

4.3.3 Strategies to Protect and Enhance the Aesthetic Aspects of Swimming and Boating

Implement improvement projects in impaired lakes: New Jersey has traditionally used Clean Lakes Program funds to address eutrophication in lakes. Projects are summarized on Table A4.3.3-1 in the Appendix. More recently, the $5 million Lakes Bond Act has been used to begin additional projects, which are summarized on Table A4.3.3-2 in the Appendix. Nonpoint Source Management Grant (319h) is an additional source of funding for lakes restoration projects

As discussed in Part II, the New Jersey Environmental Infrastructure Trust fund was used to address water quality and sedimentation issues in Colonial Lake in Mercer County. Trust funds are now being used to manage upstream sources of sediment and nutrients. This project was initiated at the municipal level. It is important to note that USEPA no longer funds the Clean Lakes Program, although funds to reinstate this program have been requested from Congress.

Develop TMDLs for impaired lakes: All eutrophic lakes identified by the Clean Lakes Program are included on the 1998 Impaired Waterbodies List. Thus these lakes are subject to the provisions and schedules of the TMDL MOA (See Part II, Appendix A2.5). As TMDLs are developed, nutrient and sediment loads and cycling in the lakes will be assessed and management measures will be prioritized and implemented.

The Governor's Lake Restoration and Management Advisory Task Force ("Lakes Task Force") See section 4.1.5 ”Strategies to Protect and Enhance Aquatic Life Uses in Lakes" located earlier in this subchapter for a description.